Environmental Planning Tools and Techniques

Linking Land Use to Water Quality Through Community-based Decision Making

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About the Cover

The cover photo by Steve Anderson, Idaho Falls Public Works Division, is a residential multifunctional landscaping technique at the intersection of St. Clair and Woodruff in Idaho Falls.

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Executive Summary

Environmental Planning Tools and Techniques presents local/regional planners and land use decision makers alternative source control measures in a menu format. Communities throughout Idaho are encouraged to use site and watershed planning to integrate the broader application of comprehensive design principles that preserve the integrity of natural landscapes. Comprehensive and integrative land-use planning, when combined with natural engineering techniques, helps to preserve and enhance natural processes and/or features already present on a site. This combined planning and engineering approach minimizes adverse environmental impacts and maximizes economic benefits in a community. Many of these measures can also enhance local ordinances by encouraging greater flexibility in the land development process.

Nonpoint source pollution is polluted runoff created when water washes over the land's surface picking up all sorts of diffuse pollutants. The realm of managing urban stormwater runoff includes existing development, as well as plans for new development. In confronting both the correction of existing and the prevention of future impacts, two categories of Best Management Practices (BMPs) are often necessary: (1) watershed planning source control measures and (2) site design treatment measures. Watershed planning source control measures are used to minimize and/or prevent the source(s) of urban stormwater pollutants.

As the natural landscape is urbanized, more and more impervious area shifts the water cycle from its natural balance. This shift results in impacts to both water quantity and water quality: increased runoff discharges to receiving waters over a shorter time frame, decreased infiltration for ground water recharge/stream baseflows, and more pollution generated by land uses commonly associated with urbanization. It is important to recognize that drainage divides of the natural landscape or watershed boundaries, do not follow the jurisdictional boundaries of society. Surface water is often interconnected to ground water, and vice versa, making the protection of one integral to the protection of the other.

Urbanization is the change in land use from rural characteristics to urban or city-like characteristics.

Changes in land use can drive changes in local water quality. The most common nonpoint source pollutants from communities are derived from (1) a multitude of pollutants derived from activities associated with impervious surfaces, and (2) the transport of fine suspended sediment from construction site activities. Impervious surfaces serve dual functions, as a source for the accumulation of pollutants and as an express route for conveying storm water to local receiving water bodies without treatment. Direct connections between impervious surfaces and a local water body via storm drains, should be minimized through source control measures. Where source control measures are not sufficient or possible, runoff derived from impervious surfaces or an area should be treated prior to discharge to receiving water bodies.

The economics of protection have demonstrated over and over that it is much cheaper and easier to prevent water pollution, than it is to clean up pollution and reverse its subsequent cumulative impact. The protection of water quality for lakes, streams, rivers, and aquifers is often dependent upon the protection of sensitive open space areas or those areas most adjacent to a waterbody. Encouraging a multiple integrative goal of protecting sensitive open space and thus, the quality of local water resources, provides communities a much greater cost benefit. A compelling argument can be made that simultaneous benefits to a community are also seen with respect to enhancing community character and quality of life, neighborhood livability, air quality, and residential road safety, among others. The link between local land use and water quality is achieved through environmental planning that integrates development initiatives around protecting sensitive open space.

There are several planning tools and techniques that can be encouraged on a county-wide or watershed scale for reducing impervious area and soil loss due to erosion and hence, protecting sensitive open space associated with site development. Four environmental planning approaches: comprehensive planning, local integrative ordinances, preserving open space, and minimizing land disturbances, provide a variety of source control alternatives to traditional forms of costly treatment mitigation. A fifth planning approach, performance criteria, provide a flexible mechanism to encourage the use of general goals when considering site specific conditions. The chosen tool and/or technique will differ greatly among communities based on their given circumstances. Drawing from a menu of alternatives based on specific local conditions should encourage a greater flexibility for individual site design and community development.

Table of Contents

Tables and Figures

Introduction

Perhaps the greatest benefit provided by natural systems is their self-maintaining capability. When used within their tolerance levels, natural systems provide a variety of services efficiently, dependably, and at no cost. This self-maintaining capability is in direct contrast to most constructed systems that require money and energy to maintain.

— Richard R. Horner, and others, 1994.

Idaho has a rich and diverse landscape with tremendous variation in the natural environment. The varying natural environment includes areas of the landscape that are more suited to urban development. However, there are other parts of the natural landscape (i.e., ponds, lakes, streams, rivers, steep slopes, riparian vegetation, etc.) that have low tolerance to intensive development. These parts of the landscape are not as well suited for development, and if radically altered, can lose their function as natural detention and filtering systems.

Stormwater runoff is a concern to most cities under arid to semi-arid conditions of the west since they are developed adjacent to streams, rivers and lakes. In particular, many Idaho cities are designed and graded to purposely convey water toward nearby water bodies. The most typical storm water quality issues are those related to runoff from impervious areas (i.e., surfaces or covers) and soil loss from site construction activities adjacent to water bodies. Stormwater runoff in urban and urbanizing areas can collect a variety of pollutants, which can be conveyed and discharged to local water bodies.

Communities throughout Idaho can use site and comprehensive planning to encourage the broader application of comprehensive design principles that preserve the integrity of the natural landscape. Comprehensive planning, when combined with natural engineering techniques can help preserve and enhance the natural features and/or processes already on a site. By doing so, this combined planning and engineering approach can minimize adverse environmental impacts and maximize economic benefits. Site and comprehensive planning carries the additional benefit of providing a preventive dimension for local resource protection.

There are several compelling reasons to provide alternatives for reducing and preventing community nonpoint source pollution to local/regional planners and land use decision makers. The predominant reasons extend from the need to protect the quality of water resources, especially those that are identified as water quality limited segments under the Clean Water Act. When not properly controlled through source and treatment measures, the process of urbanizing or developing the landscape and the various associated uses of land, generate known types of pollution and post-development site discharge volumes that are greater than pre-development levels. Superimposed upon water quality and water quantity control are the effects of rapid growth and development. With explosive growth and development and a projected continuation, there is greater imperative to protect the natural integrity of Idaho's diverse natural environment for its natural treatment functions and advocate maintaining post-development discharges at pre-development levels.

The DEQ Storm Water Program's objective is to provide education and technical assistance/support to Cities, Counties, Watershed Advisory Groups, and DEQ Regional Offices to protect and enhance surface water and ground water quality.

ORGANIZATION OF PUBLICATION

The first three chapters of the publication introduce key concepts and set the tone for tools and techniques presented in chapters 4 and 5.

The concept of sensitive open space, introduced in chapter 3, is a common theme throughout for directing site and watershed planning and development. Using environmental planning to protect sensitive open space serves a multi-functional role, serving other interests simultaneously within a community. When used as a community goal, the protection of sensitive open space is often integral in the protection of local water quality. Some of those other benefits can include improving community character and quality of life, neighborhood livability, recreational opportunities, residential road safety, and air quality, among others.

Each environmental planning tool and technique presented in Chapters 4 and 5 of this publication can be used individually or jointly to reduce impervious area, which is a predominant source of pollution based on urban and suburban-related land uses.

There are three supporting appendices that follow the text of the publication. Appendix A is a source of both qualitative and quantitative economic benefits provided by open space. Appendix B is an open space subdivision design model ordinance that can be modified based on local circumstances and needs. Appendix C is the Kootenai County *Site Disturbance Ordinance* that presents a "risk-oriented" approach for managing stormwater runoff and minimizing soil loss due to construction activities.

Chapter 1

Community Nonpoint Source Pollution

As the natural landscape is paved over, a chain of events is initiated that typically ends in degraded water resources. This chain begins with alterations in the hydrologic cycle, the way that water is transported and stored.

— Chester L. Arnold and C. James Gibbons, 1996

The quality of local water resources is directly influenced by land uses and activities. For Idaho communities and especially those that are seeing rapid growth and development, it is essential that local water quality protection be linked to land use. In natural landscapes, runoff or the portion of precipitation that ultimately reaches a water body, is generally perceived to be "clean" and not harmful to water quality. This perception seems justifiable since the quantity of pollution appears small from any one spot. However, the cumulative effect of all these small source areas can cause the deterioration of water quality through time, giving rise to nonpoint source pollution.

Nonpoint source water pollution is typically defined as pollution originating from sources which are diffuse and difficult to pinpoint, which is in direct contrast to the discrete nature of point source pollution (Table 1), where nonpoint source water pollution is caused by rainfall and snowmelt moving both over and through the ground and carrying with it a variety of pollutants associated with human land uses and activities. The Idaho Division of Environmental Quality defines nonpoint source as *a geographical area on which pollutants are deposited or dissolved or suspended in water applied to or incident on that area, the resultant mixture being discharged into the waters of the state* (Title 01, Chapter 02, Water Quality Standards and Wastewater Treatment Requirements [IDAPA 16.01.02.003.30]). Nonpoint source pollution is intermittent, highly variable, and closely related to human alterations of the landscape and hydrology of an area.

THE EFFECTS OF URBANIZATION

Urbanization (or suburbanization) is the change in land use from rural characteristics to one that is improved and being developed. In an undeveloped watershed, runoff is less pronounced and often characterized as sheet flow (shallow flow spread uniformly over the land's surface). The topographic relief of the land's natural surface eventually channels runoff toward draws and valleys, forming creeks and intermittent streams. In some cases, runoff may be stored in natural dips and depressions of the landscape; in others runoff may contribute to recharging the ground water table. As runoff collects in channels and gradually cuts deeper into the landscape, moving further down gradient, there is a coalescence in perennial stream and river valleys and often a greater contribution of baseflow from ground water.

In contrast, the land's surface within an urbanizing watershed, typically cleared and graded, is paved and concreted over by impervious surfaces. Much of the natural retention provided by vegetation and soils is eliminated (Figure 1). The storage capacity of the landscape is smoothed over and covered. Traditional engineering designs typically promote an effective conveyance network for the removal of rainfall and snow-melt (e.g., curb/gutter). The result of this improved conveyance is change in the natural hydrology and morphology of the area. In turn, an improved conveyance network generates greater stormwater runoff volume and increased peak discharges over a shorter time-frame. The impact is an increase in the magnitude and frequency of erosive bankfill flooding due to stream channel widening and incision. Lower stream baseflows may result from the decrease in ground water recharge due to reduced infiltration.

The cumulative effects caused by urbanization are not only characterized by increasing imperviousness, but increased potential for soil loss in unstable stream channels and contributions from poorly contained construction activities throughout the watershed. The changes in land use caused by urbanization are often subtle and gradual. The process of erosion degrades streams in urbanizing watersheds, as more frequent channel scouring events reflect relatively unstable conditions. Channel instability causes the loss of in-stream habitat structures (i.e., pool and riffle sequences) and reduces wetted perimeters for vegetation. In addition, erosion may provide a greater load of nonpoint source pollutants.

Table 1. *General comparisons between nonpoint source and point source factors.*

FACTORS	NONPOINT SOURCE	POINT SOURCE
Input	Non-discrete	Discrete
Pollutant Source	Diffuse	Defined ("end-or-pipe")
Discharge Frequency	Intermittent	Continuous
Toxicity	Acute	Acute or chronic
Suspended solids	Highly Variable	Regulated
Control	Best Management Practices Performance Criteria	§NPDES Permitting

Source: Davis, P.H., 1995, Factors in Controlling Nonpoint Source Impacts, in *Herricks, E.E., ed., Stormwater Runoff and Receiving Systems. §NPDES is an acronym for the National Pollutant Discharge Elimination System, an U.S. EPA permitting program.*

Impervious area may be the most feasible and inexpensive environmental indicator for addressing urban runoff pollution at both the site level and watershed scale. Two major features of impervious area are its simplicity and measurability. Used as a land development unit by local and county planners, impervious area also serves an integrative function among professions for protecting environmental quality and in turn, the quality of the community. Impervious area can be determined for present community layouts and forecasted through current zoning to indicate an expected cumulative effect on stormwater runoff in the future. Impervious area does not generate pollution, but does:

- contribute to changes in the natural hydrology of a site,
- bypass the natural pollutant treatment removal mechanism of soil,
- reflect intensive land uses that often generate pollution, and
- redirect runoff containing pollutants to water bodies.

Research during the last fifteen years shows a strong linear correlation between the health of a receiving stream and the ratio of impervious area within a watershed (Arnold and Gibbons, 1996; Schueler, 1994; Booth and Reinfelt, 1993; Schueler, 1992; Todd, 1989; Schueler, 1987; Griffin, 1980; and Klein, 1979). Table 2 summarizes the impacts associated with streams in urban and urbanizing watersheds (Schueler, 1995). Conclusions from this research show that stream health and impervious area are strongly correlated and that this correlation is not limited by geography, specific environmental indicators, or a type of field method. Stream deterioration is expected to occur at relatively low levels of impervious area (10 to 15%) when planning and control measures are not in place. (Figure 2). The threshold of initial degradation (beyond 15%) appears to be consistent across the board regardless of evaluated criteria (Arnold and Gibbons, 1996).

Table 2. *Summary of stormwater runoff impacts associated with streams in urban and urbanizing watersheds.*

Changes in stream hydrology	**Changes in stream morphology**
Increased magnitude/frequency of severe floods	Channel widening and downcutting
Increased frequency of erosive bankfull and sub-bankfull floods	Stream bank erosion/channel scour
Reduced ground water recharge	Imbedding of stream substrate
Higher flow velocities during storm events	Loss of pool/riffle structure
	Stream enclosure or channelization
Changes in stream water quality	**Changes in stream ecology**
Sediment pulse during construction	Reduced diversity of aquatic insects
Nutrient loads promote stream and lake algal growth	Reduced diversity of fish
Stream warming	Decline in amphibian populations
Bacterial pollution during dry and wet weather	Creation of barriers to fish migration
Higher loads of organic matter, metals, hydrocarbons, and priority pollutants	Degradation of wetlands, riparian zones, springs, etc.

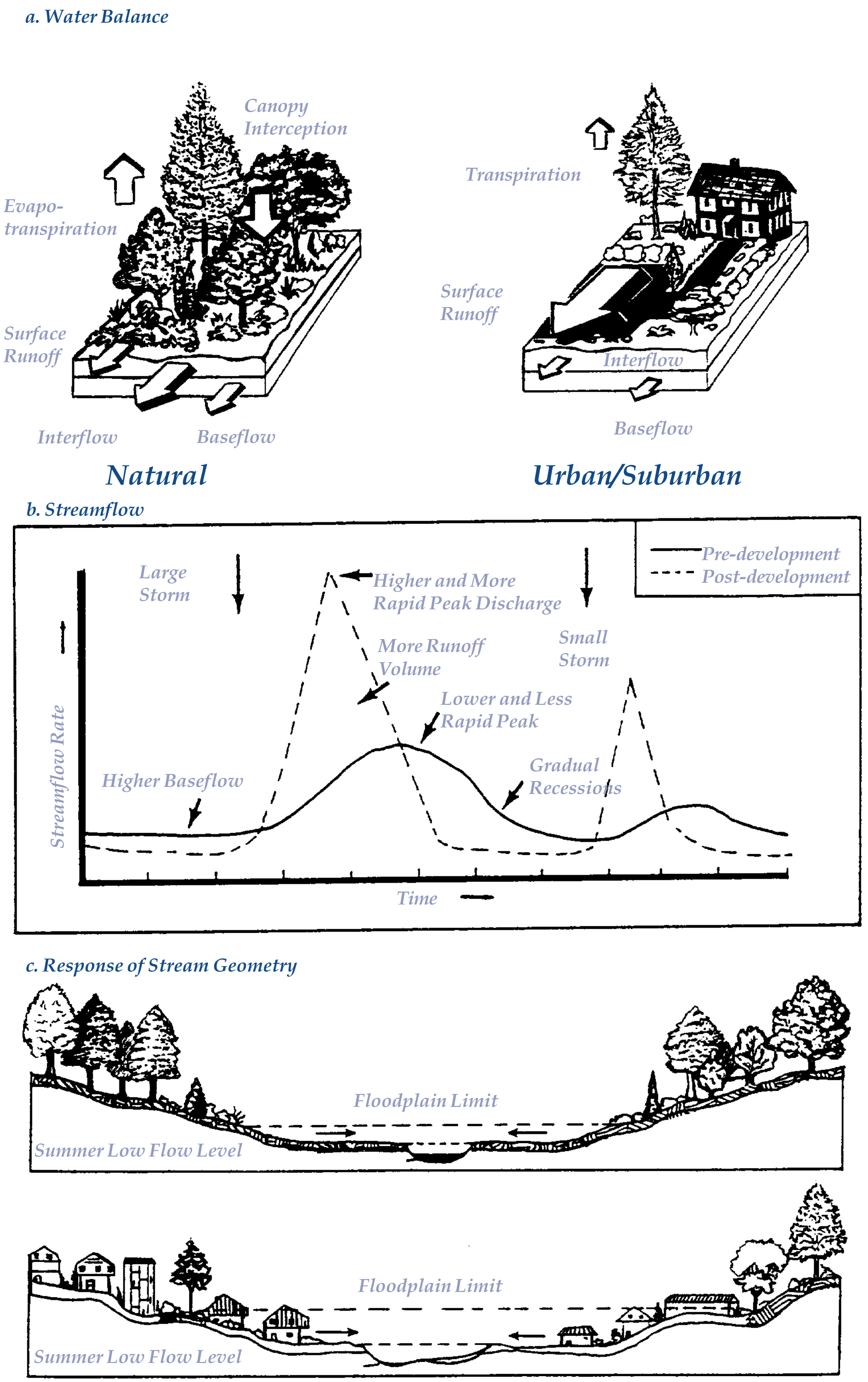

Figure 1. Changes in watershed hydrology as a result of urbanization.

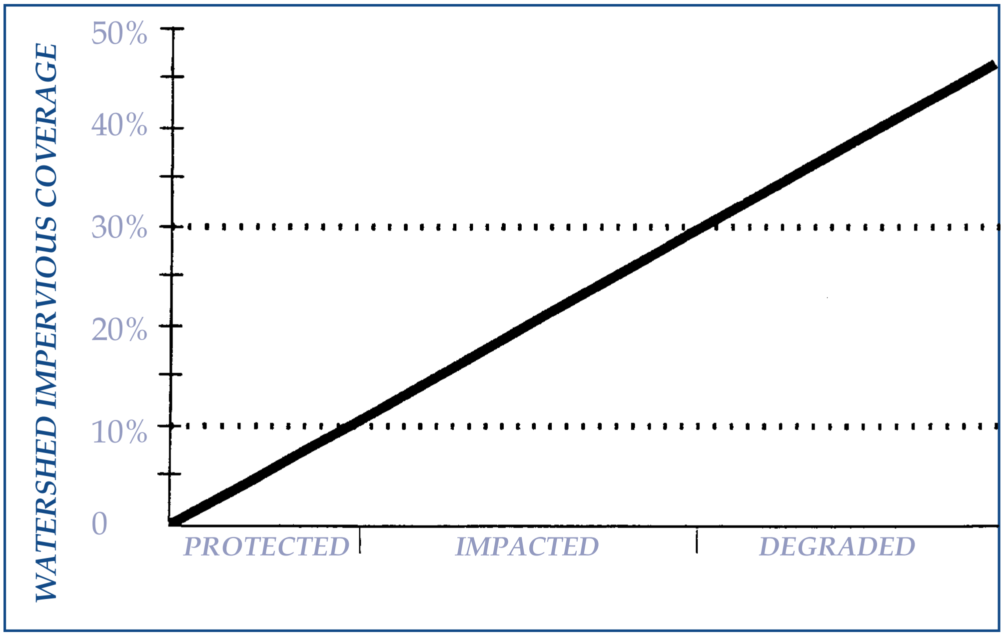

__Figure 2.__ The relation between impervious surface cover and stream health with three thresholds of stream health.

CHARACTERISTICS OF URBAN STORMWATER RUNOFF

Changes in local water quality that are caused by nonpoint source pollution result from changes in land use associated with urbanization. The most common nonpoint source pollutants from communities are derived from: (1) a multitude of accumulated pollutants from impervious areas, and (2) the transport of suspended sediment from construction site activities (Table 3). Some characteristic changes in water quality related to runoff from impervious area are:

- increased nutrient input,
- increased pathogens,
- lower concentrations of dissolved oxygen,
- increased organic matter, and
- alteration of stream temperature.

Table 3. *Urban pollutants and their impacts within urban and urbanizing watersheds.*

Runoff Pollutants	Specific Constituent	Sources	Nonpoint Source Impacts
Suspended Sediment	total suspended solids, turbidity settleable solids	construction sites, agriculture runoff, and urban/suburban	Filling of ponds, reservoirs, and lakes. Increasing turbidity reduces light for photosynthesis. Acts as a sink or source of adsorbed nutrients and toxic materials.
Nutrients	total phosphorus total nitrogen	agriculture/urban runoff, atmospheric deposition, and erosion	Contributing factor for eutrophication of receiving waterbodies. Decreased level of dissolved oxygen available for fish species.
Pathogens	fecal coliform bacteria viruses	agriculture runoff, domestic animals, urban/suburban	High concentrations cause acute health concerns, limiting swimming, boating and other recreational activities. Prevents water from being potable.
Toxic metals	zinc, copper cadmium, chromium	urban/suburban	Bioaccumulative effects contribute to: human health advisories for fish consumption and other long-term toxic stress increases on the entire ecosystem.
Petroleum hydro-carbons	oil and grease total petroleum hydrocarbons	urban/suburban agriculture runoff	Toxic effects on all levels of the food chain, contributing to immediate declines in zooplankton and benthic organisms.
Synthetic organics	solvents, polynuclear aromatic	agriculture runoff, urban/suburban	Can bioaccumulate in organisms and create toxic health hazards within the food chain.
Pesticides		urban/suburban, agriculture runoff	Can bioaccumulate in organisms and create toxic health hazards within the food chain.